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A TRIBOELECTRIC SENSOR ARRAY FOR WINDBORNE MARTIAN DUST

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Introduction

- Triboelectric Sensor Array was developed to measure electrostatic interaction between windborne dust and several polymers

- Parent Technology: MECA Electrometer for 2001 Mars Odyssey cancelled lander

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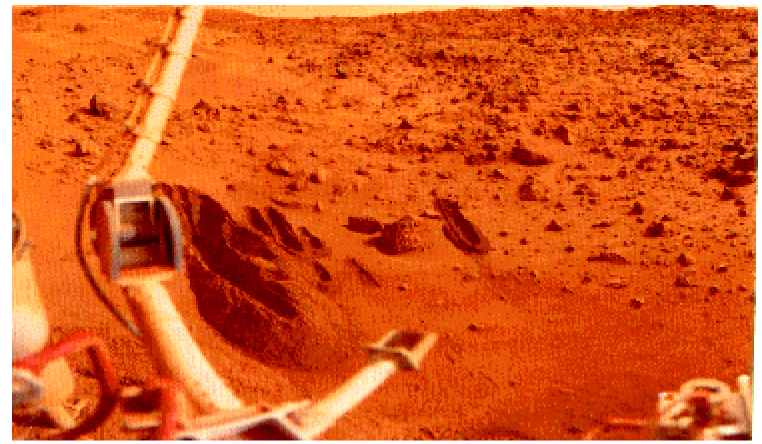
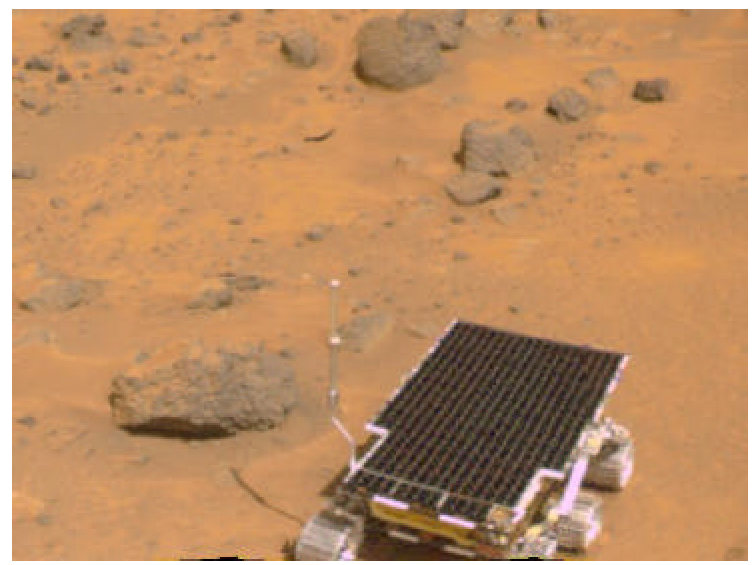
Martian Dust Environment

- Average dust particle in the Martian atmosphere: ~1 ?m in diameter
- Incident UV radiation may charge surface soil and dust particles on Mars
- Contact and frictional charge may also occur
- Future landing missions require a better understanding of electrostatic properties of dust and sand particles





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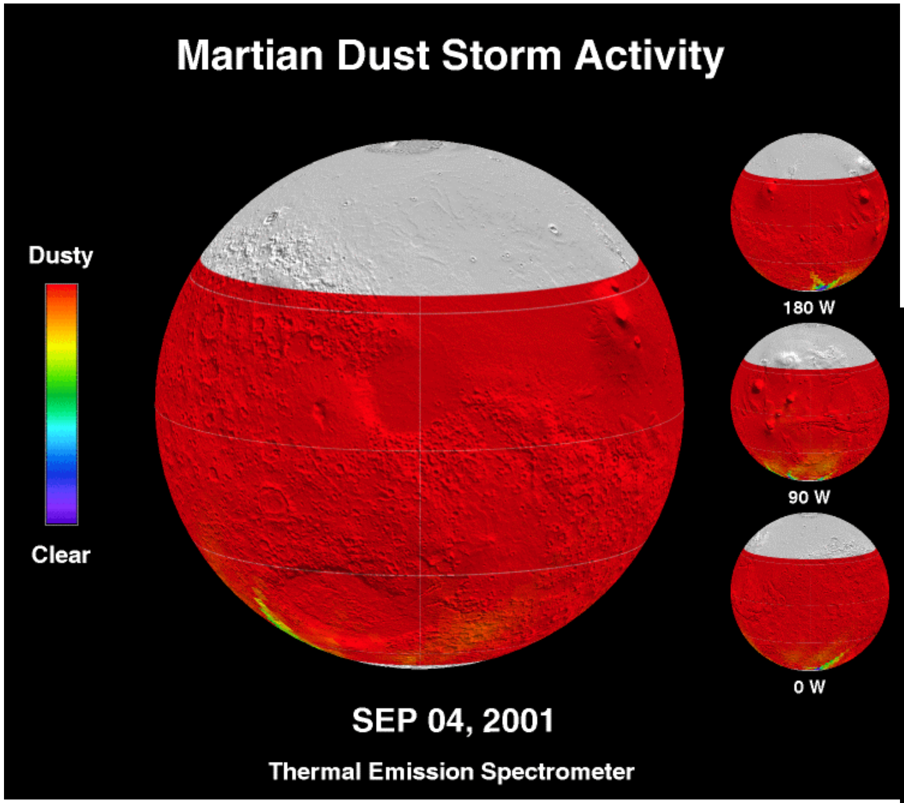
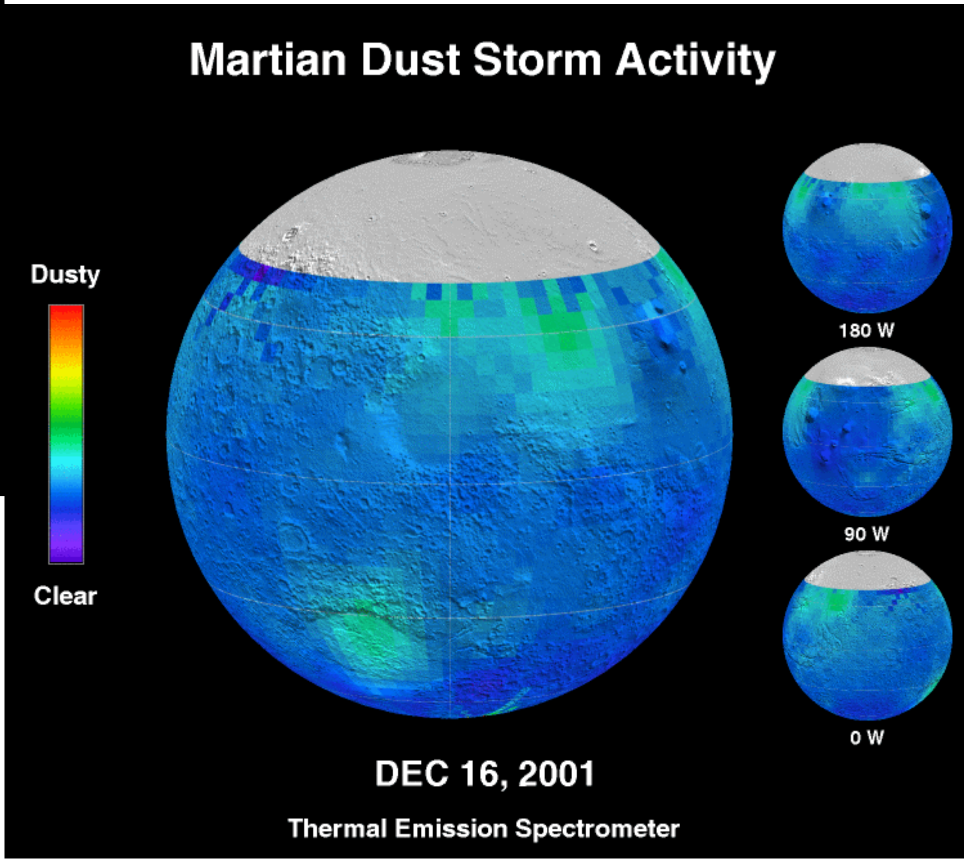
Martian Duststorms





Martian Dust Devils

- Dust devils have been observed by the Mars Global Surveyor's Orbiter Camera (MOC) to be *2 km in diameter* and *8 km in altitude*

MGS/MOC May 13, 1999

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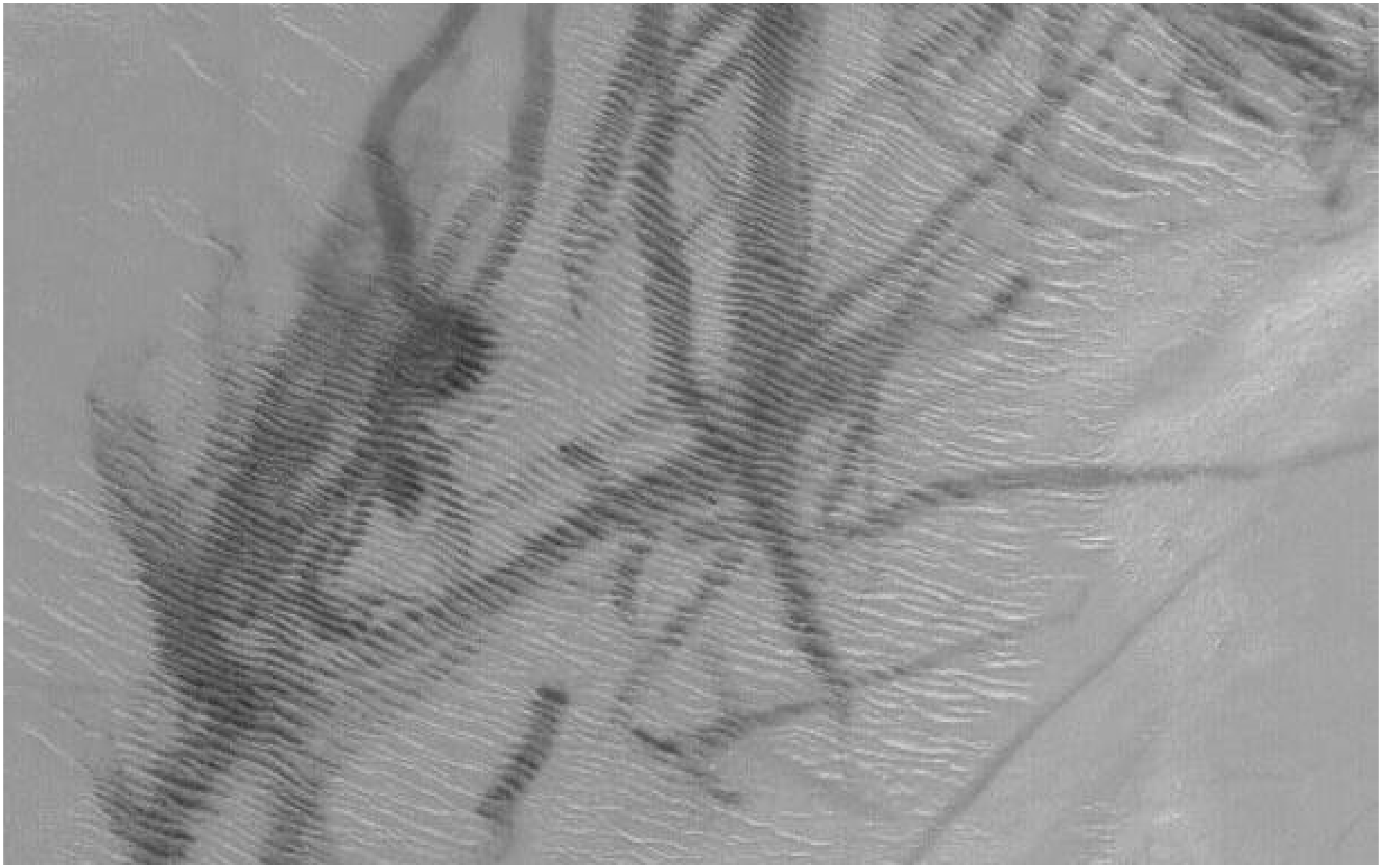
Martian Dust Devils



Electrostatic Charging

- Incident UV radiation may charge surface soil and dust particles on Mars
- Contact and frictional charge may also occur
- Future landing missions require a better understanding of electrostatic properties of dust and sand particles

Martian Electrostatic Properties

- Most of what is known comes from earth-based measurements
  - Radar, radio occultation of spacecraft, microwave radiometry
  - Consistent with direct measurements of lunar rocks
  - Low conductivities

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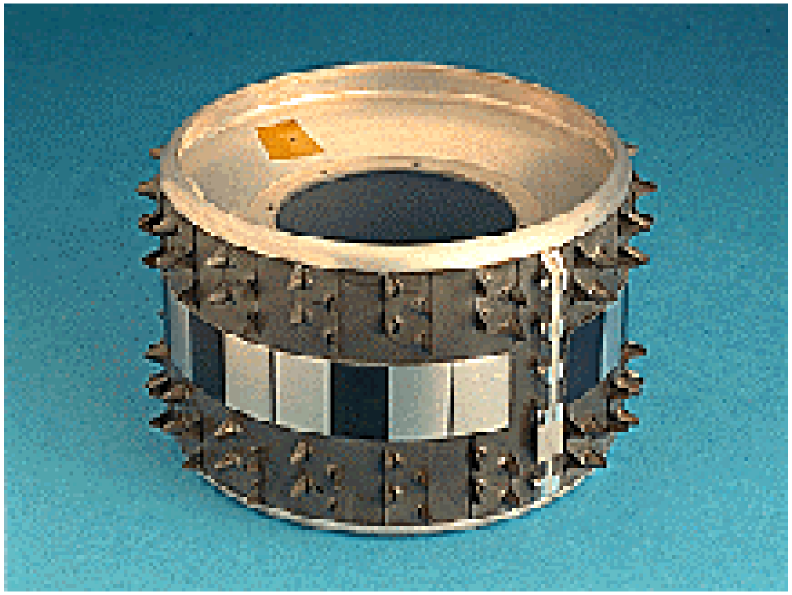
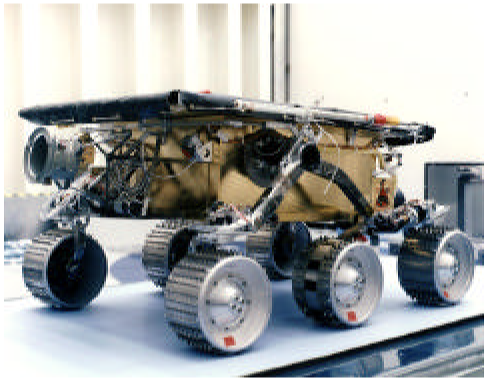
Martian *In situ* Experiment





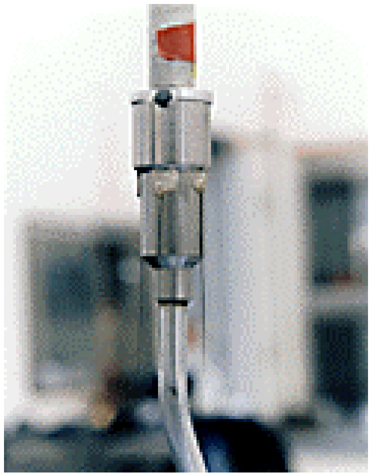
- Wheel Abrasion Experiment (WAE) on Pathfinder used thin films of Al, Ni, and Pt, (200A - 1000A), deposited on black, anodized Al strips attached to the rover wheel.
- As the wheel moved across the martian surface, a photovoltaic sensor was used to monitor changes in film reflectivity.
- Dust accumulation due to contact and frictional charging

Ground Experiments

- 1973 lab experiments in Martian-like atmosphere:
  - – Dust particle q ? 10^4 e^-
- In dusty, turbulent Martian environment:
  - – E ? 5 kV/m

Pathfinder Rover

- Model of Sojourner wheel
- SME and simulant
- Potentials ? 100 V
- Av arc times of 1?s
- *I* ? 10 mA
- Discharge points to Sojuourner antenna base



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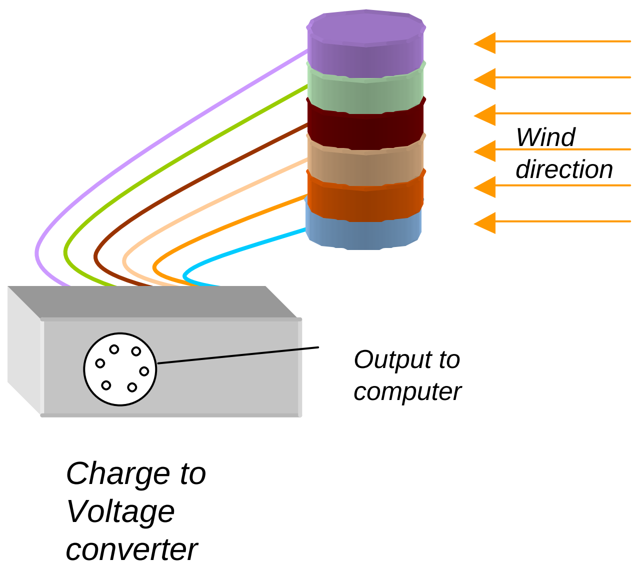
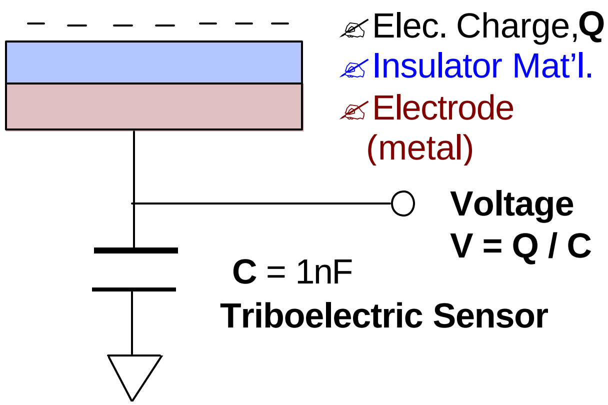
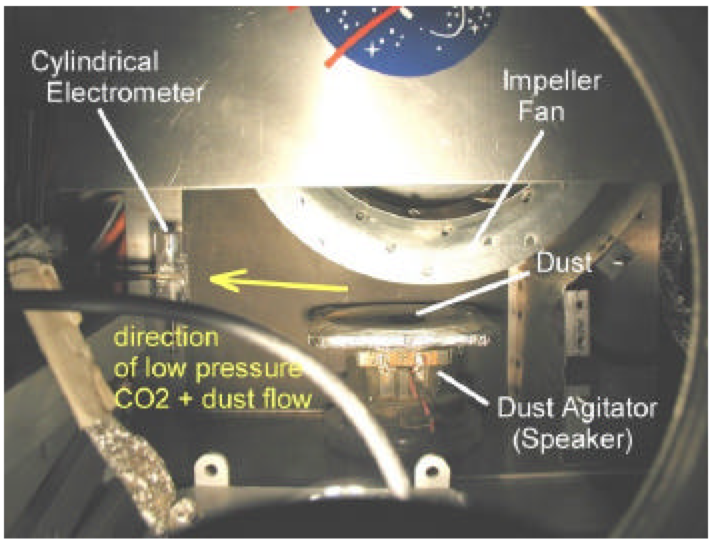
Triboelectric Multi-sensor





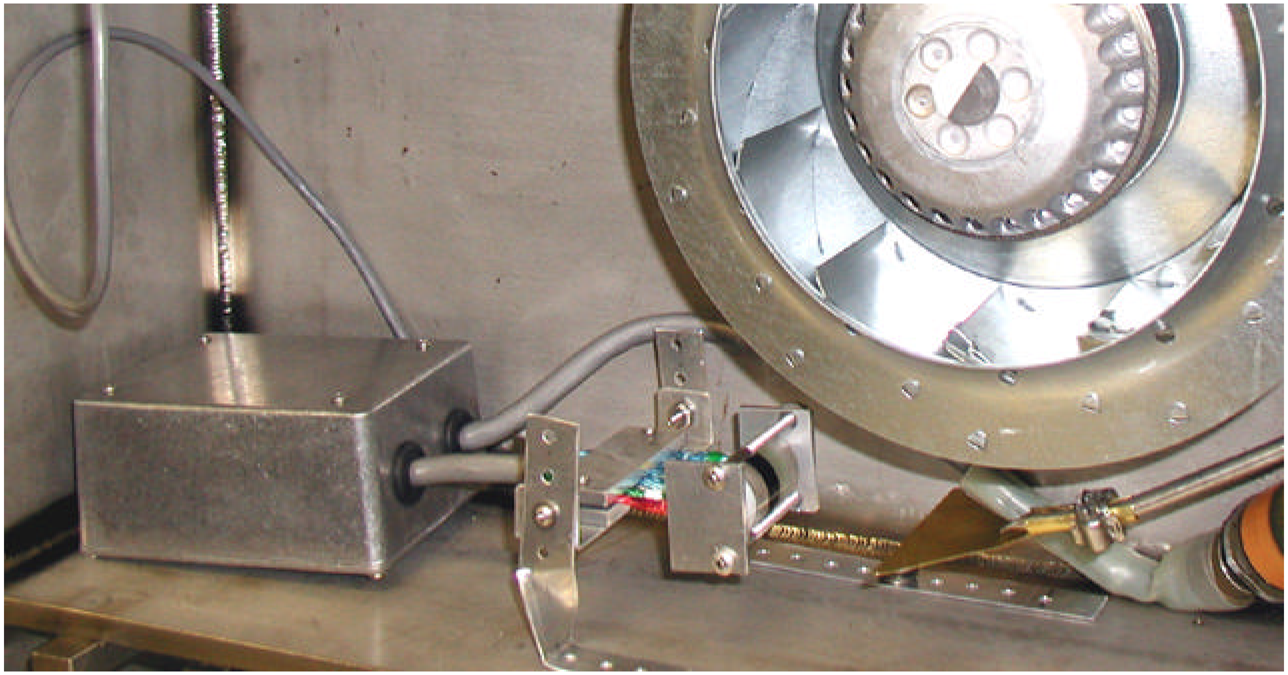
- Aerodynamic Multisensor Electrometer
- Expose different materials to "Martian" wind

Dust Impeller



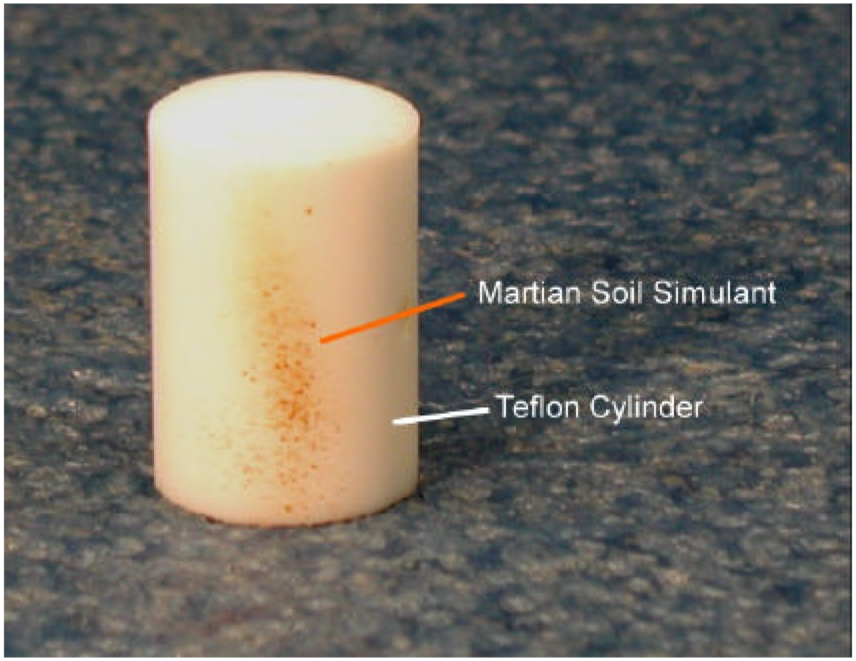
- Difficult to lift dust particles in the low atmospheric pressures near Martian surface
- Dust Impeller: vacuum chamber that uses vibrating membrane or feeder to deposit dust in front of rotating fan
- Speeds of 30 m/s

Multisensor/Dust Impeller



- Multisensor Electrometer in the Dust Impeller chamber.

Wind Simulation Experiments



- Propel 5 to 20 ?m particles at samples under SME
- Q ? -5 to + 19 pC

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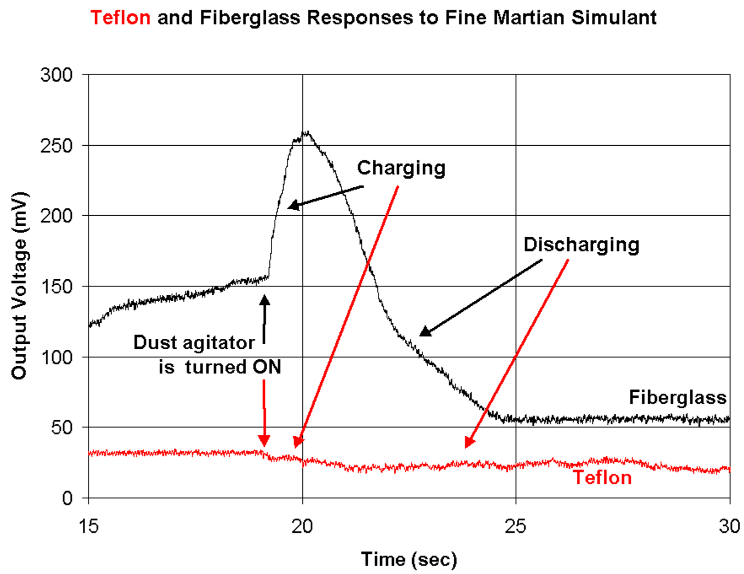
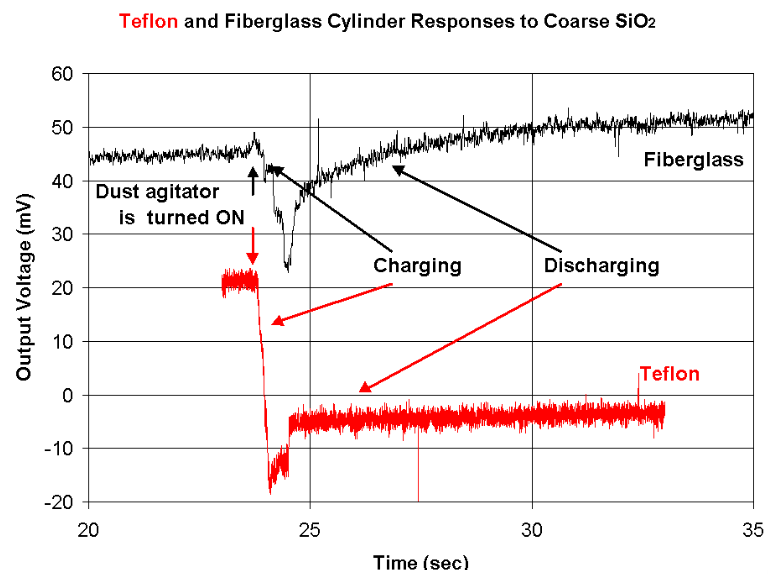
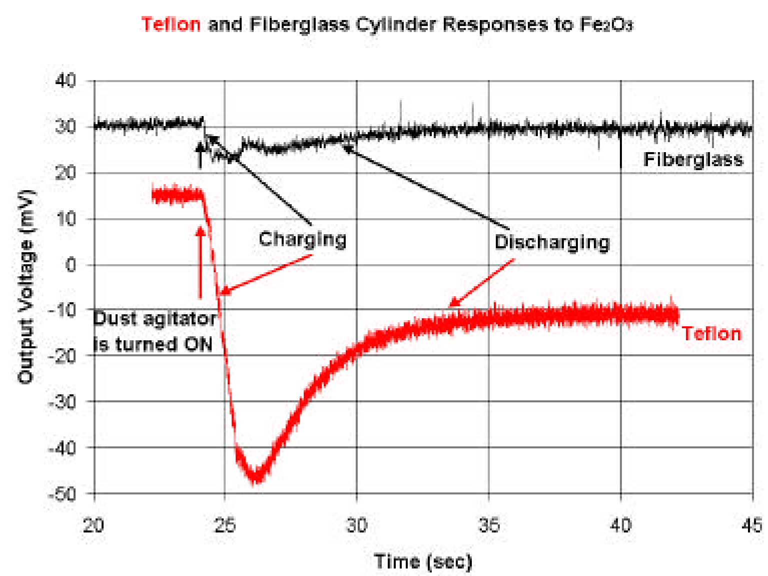
Experimental Results







- JSC Mars-1 simulant, SiO_2, and Fe_2O_3 particles on Teflon and Fiberglass
- CO_2 at 9 mbars

Triboelectric Series

Polymer	Mineral
Most Positive	
	Fe_2O_3
Fiberglass	
Lucite	
	CaO
	Al_2O_3
	SiO_2
	JSC Mars-1
Teflon	
Most Negative	

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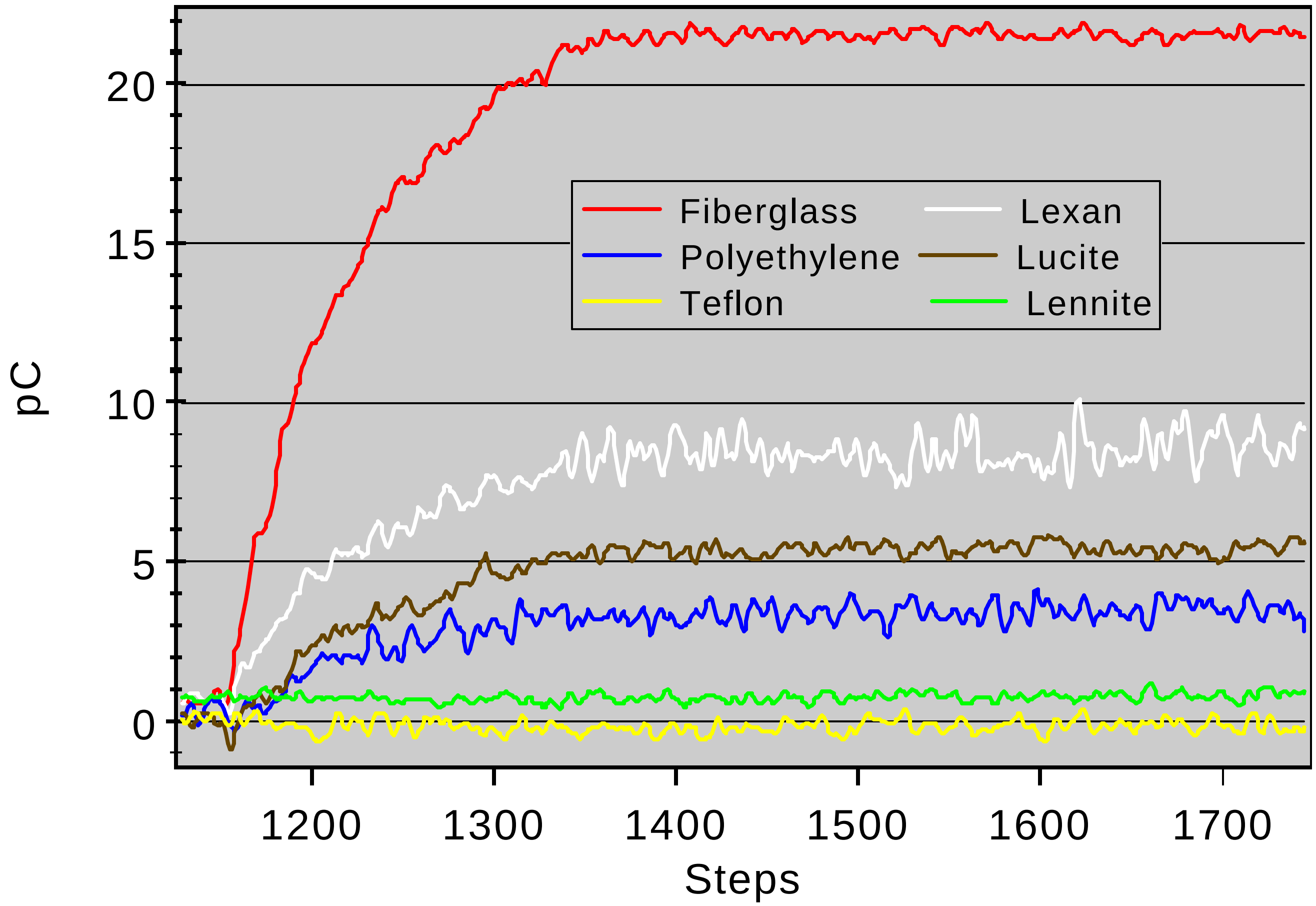
Results



- JSC Mars-1 simulant particles at 30 m/s
- CO_2 at 9 mbar

Conclusions

- Most of what we know about electrostatics on Mars: from ground based experiments
- No experiment has been flown designed solely for electrostatics
- We are currently developing instrumentation to study electrostatic properties of Martian dust
- Instruments will be proposed for future missions
- Experiments show that we can
- EMPL Website: http://empl.ksc.nasa.gov